Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.1 Explain how the law of conservation of energy applies to the transformation of various forms of energy (including mechanical energy, electrical energy, chemical energy, light energy, sound energy, and thermal energy).
Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Key Concepts:
Law of conservation of energy
Work
Energy/Energy forms: Mechanical energy, Electrical energy, Chemical energy, Light energy, Sound energy, Thermal energy
Energy transformation

Previous/Future knowledge: In the 6th grade students explained how energy can be transformed from one form to another (including the two types of mechanical energy, potential and kinetic, as well as chemical and electrical energy) in accordance with the law of conservation of energy (6-5.2). In Physical Science students will expand their concept of conservation of energy by applying the concept to transformations between various types of energy. Students will understand cause and effects relationships involved in transformations.

It is essential for students to understand that
- The *law of conservation of energy* states that energy cannot be created or destroyed. Energy can be transformed from one form to another, but the total amount of energy never changes.
- *Energy* is the property of an object or a system that enables it to do work.
  - *Work* is done when a force is applied to an object, and the object moves some distance in response to the force in the direction of the force.
  - *Work* is the product of the force applied to an object and the distance the object is moved in the direction of the force (displacement) (PS-6.3)
- If you consider a system in its entirety, the total amount of energy never changes.
- There are many different kinds of energy.
  - *Mechanical energy* is energy due to the position of something or the movement of something. Mechanical energy can be potential, kinetic, or the sum of the two.
  - *Chemical energy* is a type of energy associated with atoms, ions, and molecules and the bonds they form. Chemical energy will change to another form of energy when a chemical reaction occurs.
  - *Electrical energy* is energy associated with current and voltage.
  - *Thermal energy* is the energy associated with the random motion and arrangement of the particles of a material.
  - *Light energy* is energy that associated with electromagnetic waves.
  - *Sound energy* is energy associated longitudinal mechanical waves.
- These different kinds of energy can change from one form to another (*energy transformation*) without changing the total amount of energy. Examples might include:
  Example 1
  - Explain conservation of energy in terms of energy transformation in an electric circuit with a battery and a light bulb burning.

- Chemical energy changes to electrical energy.
- The electrical energy flows through the light bulb and turns electrical energy to light and thermal energy.
- The total of the energy from the chemical reaction in the battery is equal to the total energy that it transforms into.

Example 2

- Explain conservation of energy in terms of energy transformation when a baseball is thrown to another ball player.
  - A ballplayer converts chemical energy from the food he/she has eaten to mechanical energy when he/she moves his/her arm to throw the ball.
  - The work done on the ball converts the energy of the arm movement to kinetic mechanical energy of the moving ball.
  - As the ball moves through the air, it has both kinetic and potential mechanical energy.
  - When a second player catches the ball, the ball does work on the player's hand and glove giving them some mechanical energy.
  - The ball also moves the molecules in the glove moving them faster and thus heating the glove.
  - The player that catches the ball absorbs the energy of the ball, and this energy turns to heat.
  - The total heat produced is equal to the energy used to throw the ball.
- Most energy transformations are not 100% efficient. When energy changes from one form to another, some of the original energy dissipates in the form of energy that is not usable. Usually it dissipates as heat.

It is not essential for students to

- Explain the chemical reaction that releases chemical energy.

Assessment Guidelines:

The objective of this indicator is to *explain* how the law of conservation of energy applies to energy transformations, therefore, the primary focus of assessment should be to construct a cause and effect model showing that energy is conserved as it continually transforms from one type to another. Assessments should require that students understand transformation of different types of energy and the relationship of this transformation to the conservation of energy.

In addition to *explain*, assessments may require that students

- *Exemplify* energy transformations;
- *Compare* the forms of energy;
- *Infer* the transformations of different types of energy within given situations;
- *Summarize* major points about energy transformations;
- *Recall* the forms of energy.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.2 Explain the factors that determine potential and kinetic energy and the transformation of one to the other.
Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Key Concepts:
Potential energy
Gravitational potential energy
Kinetic energy

Previous/Future knowledge: In the 6th grade students explained how energy can be transformed from one form to another (including the two types of mechanical energy, potential and kinetic, as well as chemical and electrical energy) in accordance with the law of conservation of energy (6-5.2). In Physical Science the students will expand their concepts of kinetic and potential energy by explaining the transformations between the two and the factors involved.

It is essential for students to understand
- Transformations of potential and kinetic mechanical energy.
  - Mechanical energy is energy due to the position of an object or the movement of an object.
  - Mechanical energy can be potential or kinetic or the sum of the two.
- That *potential energy* is energy that is stored because of the arrangement of the system. Factors that affect gravitational potential energy are height and weight (mass times acceleration due to gravity, or $F_w=mg$).
  - Gravitational potential energy is greater when the height of an object is greater.
  - Gravitational potential energy is greater when the weight of the object is greater.
  - Gravitational potential energy of an object at some height is equal to the work required to lift the object to that height. Work is equal to force times distance (PS-6.3, 4); W = Fd.
- That *kinetic energy* is energy of motion. Factors that affect kinetic energy are mass and speed.
  - Kinetic energy is greater when the speed of an object is greater.
  - Kinetic energy is greater when the mass of a moving object is greater.
- Transformations can occur between gravitational potential energy and kinetic energy.
  Examples might include:
  Example 1
  - Lifting an object and dropping it
    - An object is on the ground. It has zero potential energy with respect to the ground.
    - It is lifted to some height. It now has potential energy equal to the work it took to lift it to that height. Its potential energy depends on its weight and height above the ground.
    - When the object is dropped, it is attracted by gravity and begins to speed up. Some of the energy turns to kinetic.
    - On the way down some of the energy is kinetic and some is potential, but the total remains the same.
    - Just before the object hits the ground most of the energy has turned to kinetic. It loses its potential energy because its height has gone to zero.
    - When the object hits the ground some of the energy turns to sound and some turns to heat because it speeds up molecules when it hits the ground.

Example 2

- A swinging pendulum
  - When a mass on a pendulum swings, it has mechanical energy. At the top of the swing all of its mechanical energy is potential energy that depends on its height and weight of the pendulum mass.
  - The kinetic energy is greatest at the bottom of the swing because the speed of the mass is greatest. Potential energy is zero at the bottom of the swing because the height of the mass is zero.
  - Between the top of the swing and the bottom of the swing the mass has both potential and kinetic energy because it has both height and movement (velocity).
  - Eventually the pendulum will stop. It stops because of friction.
  - The friction transforms the energy that was originally mechanical energy in the swinging pendulum into heat.

It is not essential for students to

- Calculate potential or kinetic energy using the GPE or E_P = mgh or GKE or E_k = ½ mv^2, but reference to these formulas may help with instruction.

Assessment Guidelines:

The objective of this indicator is to *explain* factors that determine kinetic and potential energy and the transformation from one to another, therefore, the primary focus of assessment should be to construct a cause and effect model of how changes in height affect potential energy and changes in velocity affect kinetic energy and how these types of energy can transform one to the other. Assessments should require that students understand the relationships of height and weight on potential energy and speed and mass to changes in kinetic energy.

In addition to *explain*, assessments may require that students

- *Compare* kinetic and gravitational potential energy;
- *Infer* effects of changes in height and speed with gravitational potential energy and kinetic energy;
- *Exemplify* kinetic and gravitational potential energy and transformations between them;
- *Summarize* major points about kinetic and gravitational potential energy and transformations between them;
- *Classify* kinetic and gravitational potential energy.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.3 Explain work in terms of the relationship among the force applied to an object, the displacement of the object, and the energy transferred to the object.
Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Key Concepts:
Work: Force, Displacement
Energy, Joule

Previous/Future knowledge: In the 6th grade students recognize that energy is the ability to do work (force exerted over a distance) (6-5.6), and also explain how the design of simple machines (including levers, pulleys, and inclined planes) helps reduce the amount of force required to do work. (6-5.7). In Physical Science the students will expand their concept of work by explaining the relationship among force, displacement, work, and energy.

It is essential for the student to understand that
- *Work* is the product of the force applied to an object and the distance the object is moved in the direction of the force (displacement).
- Force and displacement are quantities that have magnitude (an amount or size) and direction. In order to do work on an object these conditions must apply:
  - A force is applied to the object.
  - The object must move in the direction of the force.
- When work is done on an object, energy is transferred to that object.
  - Work is equal to change in energy.
  - When a net force is applied to an object and the object moves, the work is transformed to kinetic energy.
    - If a greater force is added, or
    - If the force is applied over a greater distance, then the kinetic energy will be greater.
- If an object is lifted to some height, it gains gravitational potential energy equal to the work done against gravity in lifting the object.
  - The work done against gravity is the same whether the object was lifted straight up or rolled up a ramp.
  - The greater the height, the more gravitational potential energy the object has.
- The unit of measure for work and energy is the j*oule*.

It is not essential for the student to solve problems involving kinetic energy change due to work.

Assessment Guidelines:
The objective of this indicator is to *explain* work, therefore, the primary focus of assessment should be to construct a cause and effect model that shows how a force applied in terms of direction, and distance, and size affects work and energy transformation. Assessments should require that students understand the relationships among force, distance, and energy change for gravitational potential energy as well as kinetic energy.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

In addition to *explain*, assessments may require that students
- *Infer* energy change when work is done on an object;
- *Summarize* work and energy change;
- *Exemplify* work done and resulting energy change;
- *Illustrate* situations where work is or is not done;
- *Explain* reasons why work is or is not done;
- *Recall* the definition of work.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.4 Use the formula W = Fd to solve problems related to work done on an object.
Taxonomy Level: 3.2-C Apply Procedural Knowledge

Key Concepts:
Work: Force, Displacement
Joule

Previous/Future knowledge: In the 6^{th} grade students recognized that energy is the ability to do work (force exerted over a distance) (6-5.6). In Physical Science students will expand their concept of work by developing a mathematical understanding of the concept.

It is essential for students to
- Solve problems for any variables in the equation, W = Fd, (i.e. F=W/d or d=W/F) using data.
- Use dimensional analysis to determine the proper units using the SI system:
    - Force should be given in newtons;
    - Distance should be given in meters;
    - Work will be newton-meters or joules.
- The displacement should be in the direction of the force.

It is not essential for students to solve problems involving
- Input and output work of simple machines;
- Efficiency;
- Friction;
- Power.

Assessment Guidelines:
The objective of this indicator is to *use* the formula W = Fd to solve problems related to work, therefore, the primary focus of assessment is to apply the correct procedure to mathematically determine the one of the variables in the formula W =Fd in situations involving work.

In addition to *use*, assessments may require that students:
- *Recognize* the proper units for force, distance (displacement), and work;
- *Apply* dimensional analysis to determine the proper SI units for work.

Conservation and Transformation of Energy

PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.5 Explain how objects can acquire a static electric charge through friction, induction, and conduction.
Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Key Concepts:
Static charge: Electron, Proton
Charging by friction, induction, conduction

Previous/Future knowledge: Students have not previously studied static charge.
In the 4^{th} grade students classified materials as either conductors or insulators of electricity (4-5.8).
In the 6^{th} grade students identified the sources and properties of heat, solar, chemical, mechanical, and electrical energy (6-5.1). In Physical Science students expand the concept of electrical energy. Students are introduced to the concepts of protons and electrons and their electrical properties. Students will use the understanding of these subatomic particles to explain how objects acquire a static electric charge through friction, induction, and conduction.

It is essential for students to understand that

- All matter is made up of atoms with three types of particles: protons, neutrons, and electrons. Two of the particles in atoms are electrically charged.
  - The protons, which are tightly held in the nucleus, are positively charged.
  - The electrons, which move around outside the nucleus, are negatively charged.
  - Atoms normally have the same number positive charges that they do negative charges. The effects of these charges cancel out and the object will have no net charge.
- *Static electric charge* is the result of transfer of electrons. The electrons in the atoms can be removed from the atom and moved onto something else.
  - When an object loses electrons, it will have more protons than electrons and will have a net positive charge.
  - When an object gains electrons, it will have more electrons than protons and will have a net negative charge.
- Like charges repel each other. Positive~~s~~ charges repel other positive~~s~~ charges, and negative charges repel other negative charges.
- Opposite charges attract. Negative and positive charges exert an attractive force on each other.
- Objects can be charged by:
  - *Friction*:
    - When one object is rubbed against another, sometimes electrons leave one object and stick to the other leaving both objects charged.
    - The object that loses electrons will get or have a net positive charge, and the object that gains electrons will get or have a net negative charge.
  - *Conduction*:
    - Electrons can be transferred from one object to another by touching.
    - When a charged object touches another object some charge will transfer to the other object.

        - If the charged object is negative, some of the electrons will leave the negatively charged object and travel to the neutral object leaving both objects with a negative charge.
        - If the charged object is positive, some of the electrons will leave the neutral object and travel to the positively charged object leaving both objects with a positive charge.
    - Only the electrons are transferred in solid objects.
    - Objects charged by conduction will have the same charge as the object charging it and therefore will repel it.
- *Induction*:
    - Objects can be charged by bringing a charged object near a neutral object.
    - If a charged object is brought near a neutral object the charged object will attract unlike charges in the neutral object and repel like charges in the neutral object.
    - Electrons will move in the neutral object and leave the side nearest the charged object charged with a charge that is opposite the charging object. (Only electrons can move in a solid object.)
        - If the charged object is <u>negative</u>, the electrons in the neutral object will be repelled leaving the side nearest the charged object with a <u>positive</u> charge. If the neutral object is grounded, electrons are repelled into the ground. If the ground is removed the previously neutral object will be left with a residual <u>positive</u> charge.
        - If the charged object is <u>positive</u>, the electrons in the neutral object will be attracted and move towards the positive charge leaving the side nearest the charged object with a <u>negative</u> charge. If the neutral object is grounded electrons are pulled from the ground. If the ground is removed, the previously neutral object will be left with a residual <u>negative</u> charge.
    - After an object is charged by induction, it will have the opposite charge of the charging object and will attract it.

It is not essential for the students to give specific examples of things that will charge positively or negatively by friction.

Assessment Guidelines:
The objective of this indicator is to <u>*explain*</u> how objects can acquire a static charge, therefore, the primary focus of assessment should be to construct a cause and effect model relating how friction, conduction, and induction cause static charge.

In addition to *explain*, assessments may require that students
- <u>*Compare*</u> how objects become positively and negatively charged;
- <u>*Infer*</u> effects of interactions of charges and charged objects;
- <u>*Summarize*</u> major points about how objects acquire static charge;
- <u>*Exemplify*</u> situations involving charged objects and how they are charged;
- <u>*Recall*</u> that static electric charge is the result of transfer of electrons.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.6 Explain the relationships among voltage, resistance, and current in Ohm's law.
Taxonomy Level: 2.7-B Explain Conceptual Knowledge

Key Concepts:

Voltage	Volt
Resistance	Ohm
Current	Ampere
Ohms law	

Previous/Future knowledge: In the 4th grade students summarized the functions of the components of complete circuits (including wire, switch, battery, and light bulb) (4-5.6), and also illustrated the path of electric current in series and parallel circuits (4-5.7). In the 6th grade students illustrate energy transformations (including the production of light, sound, heat, and mechanical motion) in electrical circuits (6-5.4). In Physical Science students will expand their concepts of the relationships among current, voltage, and resistance in the context of Ohm's law.

It is essential for students to understand that

- ***Voltage*** is electric potential energy per charge. It provides the energy that pushes and pulls electrons through the circuit.
  - Voltage is measured in *volts*. The symbol is (V).
  - Voltage is created by:
    - a chemical cell when it changes chemical energy to electrical energy, or
    - by a generator when it changes mechanical energy to electrical energy, or
    - by a solar cell when it changes light energy to electrical energy.
- When a wire connects the terminals of a battery or generators, then the *voltage* will push and pull electrons through a conductor.
  - One terminal has extra electrons thus a negative charge. The other terminal has a deficit of electrons and thus a positive charge.
  - Electrons in the wire are pushed by the negative terminal and pulled by the positive terminal through the wire.
- ***Electric current*** is the flow of charge through a conductor.
  - The electric current in a wire is the flow of electrons.
  - Electric current is measured in *amperes* or amps. The symbol is (A).
- Electric ***resistance*** opposes the flow of charge through a conductor. All conductors have some resistance to an electric current with the exception of some superconducting materials at very low temperatures.
  - In wires, resistance occurs when the electrons flowing through the wire continually run into metal atoms and bounce around. These collisions impede the flow of the electric current and change some of the electrical energy to thermal and/or light energy.
  - Resistance is measured in *ohms*. The symbol is (Ω).
  - Resistance will reduce the flow of current because it is harder for the current to get through the conductor.
    - When an electric current encounters resistance heat is produced.
    - Wires that have a larger diameter have less resistance.
    - Longer wires have greater resistance.

        - In many materials an increase in temperature will increase resistance.
    - Electric devices provide much of the resistance in a circuit.
- ***Ohms law*** describes the relationship between voltage, current, and resistance.
    - The voltage (V) is the product of the current (I) and resistance (R). (V = I R)
    - One volt will pull one amp of current through one ohm of resistance.
    - If the voltage increases and the resistance remains the same, the current will increase.
    - If the voltage stays the same and the resistance increases, then the current will decrease.

It is not essential for students to know
- The number of electrons in a coulomb;
- The term electromotive force or potential difference;
- About superconductors;
- About resistivity of materials.

Assessment Guidelines:
The objective of this indicator is to *explain* the relationship among voltage, resistance, and current in Ohm's law, therefore, the primary focus of assessment should be to construct cause and effect models showing these relationships.

In addition to *explain*, assessments may require that students
- *Compare* the concepts of voltage, current, and resistance;
- *Summarize* major points about voltage, current and resistance;
- *Infer* what will happen when one of the variables changes.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.7 Use the formula V = IR to solve problems related to electric circuits.
Taxonomy Level: 3.2-C Apply Procedural Knowledge

Key Concepts:
Ohms law: V = IR

Previous/Future knowledge: In the 4th grade students summarized the functions of the components of complete circuits (including wire, switch, battery, and light bulb) (4-5.6), and also illustrated the path of electric current in series and parallel circuits (4-5.7). In Physical Science students expand the concepts of voltage, current, and resistance by developing a mathematical understanding of the concept.

It is essential for students to understand
- That "V" stands for voltage, "I" stands for current, "R" stands for resistance.
- The components of an electric circuit:
  - Sources of voltage are chemical cells (a battery is a combinations of cells), solar cells, and generators.
  - Sources of resistance are resistors, light bulb filaments, and other electric devices.
- The units for:
  - *Voltage* is the volt (symbol is V).
  - *Current* is ampere or amp (symbol is A).
  - *Resistance* is ohm (symbol is Ω).

It is also essential that students are able to
- Solve problems that involve simple circuits;
- Solve for any of the variables in the equation (V=IR or I=V/R or R=V/I).

It is not essential for students to find
- Total resistance in a series or parallel circuit;
- The voltage drop across a resistance;
- The total voltage for batteries with different combinations of cells.

Assessment Guidelines:
The objective of this indicator is to *use* the formula V = IR to solve problems related to electric circuits, therefore, the primary focus of assessment should be to apply the correct procedure to mathematically determine one of the variables in the formula, V = I R, for situations involving any simple circuit.

In addition to *use*, assessments may require that students
- *Recognize* the symbols and units for voltage, current, and resistance.

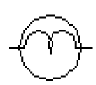
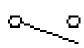
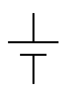
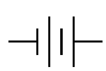
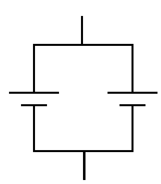
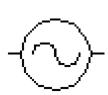
Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.8 Represent an electric circuit by drawing a circuit diagram that includes the symbols for a resistor, switch, and voltage source.
Taxonomy Level: 2.1-B Understand Conceptual Knowledge

Key Concepts:
Circuits: parallel circuit, series circuit
Circuit components: resistor, switch, wire, light bulb
Voltage sources: chemical cell, battery with cells in series, battery with cells in parallel, generator

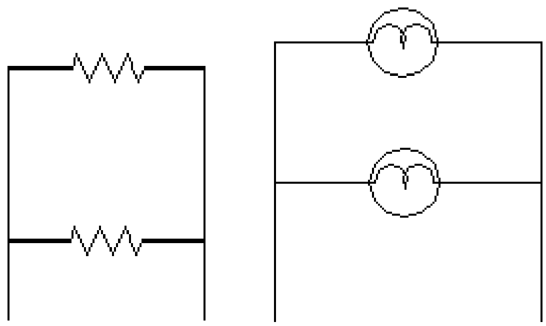
Previous/Future knowledge: In the 4th grade students summarized the functions of the components of complete circuits (including wire, switch, battery, and light bulb) (4-5.6), and also illustrated the path of electric current in series and parallel circuits (4-5.7). In Physical Science the students will expand the concepts of circuits by representing them with circuit diagrams.

It is essential for students to
- Understand the components that can be used in an electric circuit;
- Be able to represent the components of a complete circuit with symbols:

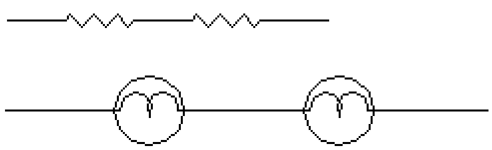
Wires	
Resistors	
Light bulbs	
Switches	
Chemical cell	
Battery circuit with 2 cells wired in series	
Battery circuit with 2 cells wired in parallel.	
AC source (generator)	

It is also essential for students to

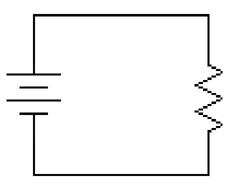
- Represent a circuit with resistors or light bulbs wired in parallel. (See PS-6.9)

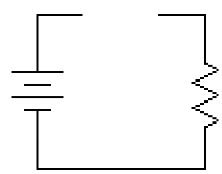


- Represent a circuit with resistors or light bulbs wired in series. (See PS-6.9)



- Represent circuits by drawing a circuit diagram from a circuit which is pictured or described.
- Interpret a circuit diagram.
- Draw an open and a closed circuit. Examples:





Closed circuit with a battery and a resistor   Open circuit with a battery and a resistor

It is not essential for students to represent devices not listed above.

Assessment Guidelines:
The objective of this indicator is to *represent* an electric circuit by drawing a circuit diagram including symbols for resistor, switch, and voltage source, therefore, the primary focus of assessment should be to draw an electric circuit utilizing symbols for the major components of the circuit.

In addition to *represent* students should be able to

- *Interpret* diagrams of electric circuits utilizing symbols for the components of the circuit;
- *Illustrate* circuit diagrams;
- *Exemplify* symbols and diagrams.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.9 Compare the functioning of simple series and parallel electrical circuits.
Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Key Concepts:
Resistors wired in series
Resistors wired in parallel
Batteries made from cells wired in series
Batteries made from cells wired in parallel

Previous/Future knowledge: In the 4th grade students summarized the functions of the components of complete circuits (including wire, switch, battery, and light bulb) (4-5.6), and also illustrated the path of electric current in series and parallel circuits (4-5.7). In Physical Science students will expand their concepts of series and parallel circuits by comparing them and their functions.

It is essential for students to recognize and understand

Series Circuits:
- In a series circuit there is a single path for electrons.
- When another resistor is wired in series with the resistors in a circuit, the total resistance increases because all of the current must go through each resistor and encounters the resistance of each.
- The current in the circuit decreases when additional resistors are added.
  - When another light bulb is added to lights wired in series, the lights will dim.
  - The current will be the same in each resistor.
- When light bulbs are wired in series and one is removed or burns out all of the lights in the circuit go out. When the light bulb is removed from the circuit, it opens the circuit and current cannot flow.

Parallel circuits:
- When resistors are wired in parallel, there is more than one path that the electrons can travel.
- The voltage in each path is the same.
- When another resistor is wired in parallel, then the total resistance is reduced.
- The total current in the circuit will increase when another path is added.
- If light bulbs are wired in parallel and one bulb burns out or is removed, the other bulbs keep burning because the circuit is still complete.

Chemical cells in series and parallel:
- Chemical cells can be wired in series to make a battery.
  - Cells wired in series will increase the voltage of the battery.
- Chemical cells can be wired in parallel to make a battery.
  - Cells wired in parallel do not change the voltage of the battery.
  - Cells are wired in parallel to make the battery last longer.

It is not essential for students to
- Calculate the total resistance in a series or parallel circuit;
- Calculate the current in each branch of a parallel circuit;
- Calculate the total voltage of a battery when the cells are wired in series or parallel.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

Assessment Guidelines:
The objective of this indicator is to *compare* the functioning of parallel and series circuits, therefore, the primary focus of assessment should be to show similarities and differences between these circuits with regard to their structure and how these circuits function in different situations.

In addition to *compar*e, students should be able to:
- *Illustrate* series and parallel circuits;
- *Classify* circuits as series or parallel;
- *Summarize* major points about series and parallel circuits;
- *Infer* the effects of changes in series and parallel circuits;
- *Recognize* series and parallel circuits.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.10 Compare alternating current (AC) and direct current (DC) in terms of the production of electricity and the direction of current flow.
Taxonomy Level: 2.6-B Understand Conceptual Knowledge

Key Concepts:
Alternating current (AC): Generator, Electromagnetic induction
Direct current (DC): Battery, Chemical cell

Previous/Future knowledge: In the 4th grade students illustrated the path of electric current in series and parallel circuits (4-5.7). In the 6th grade students explained how magnetism and electricity are interrelated by using descriptions, models, and diagrams of electromagnets, generators, and simple electrical motors (6-5.3). In Physical Science the concept of electric current is expanded. Students will understand the movement of the electric current and understand how AC and DC current are produced.

It is essential for students to understand
- That electric current in a wire is the flow of electrons.
- *Direct current (DC)*: DC current or direct current flows in one direction.
  - DC current can be produced using a solar cell or a chemical cell. A battery is a combination of chemical cells. (Strictly speaking a battery is a combination of more than one cell. Sometimes a "D cell" is referred to as a battery. This causes confusion with students.)
  - Electrons are repelled by the negative terminal of a battery and attracted to the positive terminal of a battery.
  - When a circuit is connected to the terminals the electrons will move from the negative terminal to the positive terminal.
- *Alternating current (AC)*: AC current or alternating current moves back and forth.
  - The electric current that comes out of the outlets in our homes and schools is AC current.
  - AC current can be produced by a generator using the principle of *electromagnetic induction*. The current is produced when a magnet moves relative to a coil of wire.
  - In a generator the magnet (or coil) spins causing the terminals of the generator to alternate between positive and negative.
  - Electrons are repelled by the negative terminal and attracted to the positive terminal just as in DC currents.
  - Since the terminals are continually changing from positive to negative the current continually changes direction.

It is not essential for students to know the number of times poles switch in a generator.

Assessment Guidelines:
The objective of this indicator is to *compare* AC and DC current with regard to production and current flow, therefore, the primary focus of assessment should be to show similarities and differences between DC and AC current and to understand why each type of current moves the way it does.

In addition to *compar*e, students should be able to
- *Exemplify* AC and DC current and how each is produced;
- *Classify* current as either AC or DC;
- *Summarize* major points about AC and DC current.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.11 Explain the relationship of magnetism to the movement of electric charges in electromagnets, simple motors, and generators.
Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Key Concepts:

Electromagnet	Core
Motor	Armature
Generator	Electromagnetic induction

Previous/Future knowledge: In the 6th grade students explain how magnetism and electricity are interrelated by using descriptions, models, and diagrams of electromagnets, generators, and simple electrical motors (6-5.3). In Physical Science students expand their concepts of the relationships of magnetism and electricity. They will develop a concept of electric current and its relationship to magnetism in electromagnets, generators, and simple electric motors.

It is essential for students to understand

- *Electromagnets:*
  - Electric currents in wires produce magnetic fields around the wire.
  - The magnetic field can be concentrated and thus strengthened in several ways:
    - Wrapping the wire in a coil will strengthen the electromagnet. The greater the number of turns in the coil, the greater the increase in strength.
    - Adding a *core* (like iron) will concentrate the magnetic field and strengthen the electromagnet.
    - Increasing the current in the coil will strengthen the electromagnet.
- *Motors*:
  - Electric motors change electrical energy to mechanical energy.
    - Motors contain an electromagnet called an *armature*. When an electric current runs through the wire in the armature it becomes magnetized.
    - The armature spins because other magnets in the motor push and pull the armature and cause it to spin.
    - Motors use the magnetic force from magnets to spin an armature (magnetized by an electric current) and thus change electric energy to mechanical energy.
- *Generators:*
  - A generator changes mechanical energy into electric energy.
  - Generators use electromagnetic induction to produce an electric current.
    - When a wire or a coil of wire moves relative to a magnetic field an electric current can be produced. This process is called *electromagnetic induction*.
    - In a generator at a power plant some other type of energy such as the energy in stream is used to turn a turbine which spins a magnet in a generator. The magnet spins past a coil of wire. This moving magnetic field pushes electrons through the wire.
  - A generator is similar to an electric motor. (A generator is an electric motor working in reverse.)
  - Generators produce AC current.

Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

It is not essential for students to
- Label the parts of a motor or generator;
- Compare the permeability of different core materials;
- Describe different types of motors or generators;
- Describe the function of a transformer.

Assessment Guidelines:
The objective of this indicator is to *explain* the relationship of magnetism to the movement of electric charges, therefore, the primary focus of assessment should be to construct a cause and effect model that shows the relationship of electricity and magnetism within electromagnets, motors, and generators.

In addition to *explain*, assessments may require that students:
- *Compare* motors and generators;
- *Summarize* major points about electric motors, generators, and electromagnets;
- *Summarize* electromagnetic induction.
- *Identify* electromagnets, motors, and generators from illustrations.